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Summary

An aspect of the invention relates to the problem of providing equipment for analysing the condition of a machine satisfying the conflicting requirements of reducing the price for a piece of condition monitoring equipment while maintaining profitability for the supplier of the analysis system.

This problem is addressed by an apparatus for analysing the condition of a machine, comprising:

An apparatus for analysing the condition of a machine, comprising:

at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine;

data processing means for processing condition data dependent on said measurement data; said data processing means comprising means for performing a plurality of condition monitoring functions (F1, F2,Fn); and

a logger for registering use of at least one of said condition monitoring functions (F1, F2,Fn).

This advantageously enables charging a cost for use of the apparatus.

An embodimnent of the apparatus comprising:

a communication port (16); wherein

said apparatus is adapted to be capable of delivering data indicative of said registered use on said communication port (16).

This advantageously enables delivery of use info to a supplier, for charging a cost. i.e. reporting the amount of use to the supplier.

An embodiment of the apparatus further comprises:

means for comparing said registered use with a first reference value,

means for disabling said data processing means or at least one of said condition monitoring functions (F1, F2,Fn) in response to the outcome of said comparison.

This solution encourages a user to buy additional usage so as to maintain operability of desired functions of the analysis apparatus. Such additional usage may be in the form of a number of measurements using a desired function, or a period of time the duration of which is defined by the registered use and the first reference value.

An embodiment of the apparatus further comprises:key reception means adapted to allow further use of said data processing means in response to reception of a first key.

This advantageously enables a supplier to amend the relation between a registered use value and the reference value. Thereby it is possible to increase "the stored amount of use" available before the data processing means is disabled.

An embodiment of the apparatus further comprises:

key reception means adapted to allow further use of a selected one of said condition monitoring functions (F1, F2,Fn) in response to reception of a key associated with said selected function.

This advantageously enables a supplier to amend the relation between the reference value and a registered use value for a selected function. Thereby it is possible to increase "the stored amount of use" available before the selected function is disabled.

An embodiment of the apparatus further comprises:

means for reading a current value of said registered use;

means for comparing said current value with a second reference value;

means for registering use at a first rate when said current value is above the second reference value; and

means for registering use at a second rate when said current value is below the second reference value.

This advantageously enables a supplier to sell usage at different costs. When, according to one embodiment, a user has paid for a certain amount A_p of usage, the second reference value is a level indicating that the whole amount A_p of usage has been spent. This means that any further use will be usage which has not yet been paid for. By the feature of registering such further use at a second rate it is possible to charge a higher cost per unit of usage for such further use.

An embodiment of the apparatus wherein:

at least some of said plurality of condition monitoring functions (F1, F2,Fn) is at least partly embodied by computer program code.

An aspect of the invention relates to the problem of achieving a cost-effective improvement of the length of life of machines with a moving part.

An aspect of the invention relates to the problem of achieving an analysis apparatus for evaluating the condition of a machine,

This problem is addressed by

An apparatus for monitoring the condition of a machine, comprising:

at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine;

data processing means for processing condition data dependent on said measurement data; said data processing means comprising means for performing a at least two condition monitoring functions (F1, F2,Fn);

at least one of said plurality of condition monitoring functions (F1, F2,Fn) having a locked state and an unlocked state; said locked state prohibiting complete execution of said condition monitoring function; and said unlocked state allowing execution;

means for changing the state of a selected condition monitoring function (F1, F2,Fn) between the locked state and the unlocked state.

This advantageously provides the analysis apparatus with an improved versatility. A manufacturer can manufacture the apparatus in a single fashion, and a supplier can sell the apparatus in several versions. More precisely, an apparatus having two individually lockable/unlockable functions can be provided in the following versions:

with only the first function unlocked;
with only the second function unlocked;
with the first function and the second function unlocked.

Hence, a supplier can offer the apparatus in three versions, and this allows for selling it at different price levels dependent on the functionality included. Each client is therefore provided with a choice as to which functions to choose.

An embodiment of the apparatus further comprises:

key reception means adapted to allow use of a selected one of said condition monitoring functions (F1, F2,Fn) in response to reception of a key associated with said selected function;

a logger for registering use of at least one of said condition monitoring functions (F1, F2,Fn).

means for comparing said registered use with a first reference value,

means for disabling said data processing means or at least one of said condition monitoring functions (F1, F2,Fn) in response to the outcome of said comparison.

Hence, A manufacturer can manufacture the apparatus in a single fashion, and a supplier can sell the apparatus in more than four versions:

with only the first function unlocked;

with only the second function unlocked;

with the first function and the second function unlocked.

with both functions locked but each function individually or collectively unlockable for a limited amount of use.

Detailed Description of Embodiments

In the following description similar features in different embodiments may be indicated by the same reference numerals.

Fig. 1 shows a schematic block diagram of an embodiment of a condition analyzing system 2 according to an embodiment of the invention. Reference numeral 4 relates to a client location with a machine 6 having a movable part 8. The movable part may comprise bearings 7 and a shaft 8 which, when the machine is in operation, rotates. The location 4, may for example be the premises of a paper mill plant, or some other manufacturing plant having machines with movable parts.

An embodiment of the condition analyzing system 2 is operative when a sensor 10 is firmly attached on or at a measuring point 12 on the body of the machine 6. Although Figure 1 only illustrates two measuring points 12, it to be understood that a location 4 may comprise any number of measuring points 12. The condition analysis system 2 shown in Figure 1, comprises an analysis apparatus 14 for analysing the condition of a machine on the basis of measurement values delivered by the sensor 10.

The analysis apparatus 14 has a communication port 16 for bi-directional data exchange. The communication port 16 is connectable to a communications network 18, e.g. via a data interface19. The communications network 18 may be the world

wide internet, also known as the Internet. The communications network 18 may also comprise a public switched telephone network.

A server computer 20 is connected to the communications network 18. The server 20 may comprise a database 22, user input/output interfaces 24 and data processing hardware 26. The server computer 20 is located on a location 28, which is geographically separate from the client location 4. The server location 28 may be in a first city, such as the Swedish capital Stockholm, and the client location may be in another city, such as Stuttgart, Germany or Detroit in Michigan, USA. Alternatively, the server location 28 may be in a first part of a town and the client location may be in another part of the same town.

Fig. 2 is a schematic block diagram of an embodiment of a part of the condition analyzing system 2 shown in Fig 1.The condition analyzing system, as illustrated in Fig. 2, comprises a sensor unit 10 for producing a measured value. The measured value may be dependent on movement or, more precisely, dependent on vibrations. Alternatively the measured value may be dependent on temperature.

An embodiment of the condition analyzing system 2 is operative when a device 30 is firmly mounted on or at a measuring point on a machine 6. The device 30 mounted at the measuring point may be referred to as a stud 30. A stud 30 can comprise a connection coupling 32 to which the sensor unit 10 is removably attachable. The connection coupling 32 can, for example comprise double start threads for enabling the sensor unit to be mechanically engaged with the stud by means of a ¼ turn rotation.

A measuring point 12 can comprise a threaded recess in the casing of the machine. A stud 30 may have a protruding part with threads corresponding to those of the recess for enabling the stud to be firmly attached to the measuring point by introduction into the recess like a bolt.

Alternatively, a measuring point can comprise a threaded recess in the casing of the machine, and the sensor unit 10 may comprise corresponding threads so that it can be directly introduced into the recess. Alternatively, the measuring point is marked on the casing of the machine only with a painted mark.

The machine 6 exemplified in Fig. 2 may have a rotating shaft with a certain shaft diameter d1. The shaft in the machine 24 may rotate at a certain speed of rotation V1 when the machine 6 is in use.

The sensor unit 10 may be coupled to the apparatus 14 for analysing the condition of a machine. The analysis apparatus 14 comprises a sensor interface 40 for receiving a measured signal or measurement data, produced by the sensor 10. The sensor interface 40 is coupled to a data processing means 50 capable of controlling the operation of the analysis apparatus 14 in accordance with program code. The data processing means 50 is also coupled to a memory 60 for storing said program code.

According to an embodiment of the invention the sensor interface 40 comprises an input 42 for receiving an analog signal, the input 42 being connected to an analogue-to-digital (A/D) converter 44, the digital output of which is coupled to the to the data processing means 50.

The program memory 60 is preferably a non-volatile memory. The memory 60 may be a read/write memory, i.e. enabling both reading data from the memory and writing new data onto the memory 60. According to an embodiment the program memory 60 is embodied by a FLASH memory. The program memory 60 may comprise a first memory segment 70 for storing a first set of program code 80 which is executable so as to control the analysis apparatus 14 to perform basic operations (Figure 2 and Figure 3). The program memory may also comprise a second memory segment 90 for storing a second set of program code 100.

According to some embodiments of the invention the second set of program code is initially disabled so as to prohibit execution of said second set of program code. The disabled data 100 may be enabled in response to reception of a key.

According to an embodiment of the invention the apparatus 14 comprises an interface means for receiving the key.

Figure 3 is a simplified illustration of an embodiment of the memory 60 and its contents. The simplified illustration is intended to convey understanding of the general idea of storing different program functions in memory 60, and it is not necessarily a correct technical teaching of the way in which a program would be stored in a real memory circuit. The first memory segment 70 stores program code for controlling the analysis apparatus 14 to perform basic operations. Although the simplified illustration of Figure 3 shows pseudo code, it is to be understood that the program code 80 may be constituted by machine code, or any level program code that can be executed or interpreted by the data processing means 50 (Fig.2).

The second memory segment 90, illustrated in Figure 3, stores a second set of program code 100. The program code in segment 90, when run on the data processing means 50, will cause the analysis apparatus 14 to perform an added function. The added function may comprise an advanced mathematical processing of a measured signal received via the sensor interface 40. The added function, however, will be enabled and available only if the corresponding key or key word has been entered.

A keyword embodiment

According to an embodiment of the analysis apparatus 14 (Figure 2), the interface means comprises a user input interface 102, whereby an operator may introduce the

key in the form of a code word, also referred to as key word. According to this embodiment the first set of program code 80 in the apparatus 14 comprises a program routine for requesting a code word, and for determining whether a received code word is accepted. According to an embodiment the user input interface 102 comprises a set of buttons 104. An embodiment of the analysis apparatus 14 comprises a user output interface. The user output interface may comprise a display unit 106. The data processing means 50, when it runs a basic program function provided in the basic program code 80, provides for user interaction by means of the user input interface 102 and the display unit 106. The set of buttons 104 may be limited to a few buttons, such as for example five buttons, as illustrated in Figure 2. A central button 107 may be used for an ENTER or SELECT function, whereas other, more peripheral buttons may be used for moving a cursor on the display 106. In this manner it is to be understood that symbols and text, such as the above mentioned code word, may be entered into the apparatus 14 via the user interface. The display unit 106 may, for example, display a number of symbols, such as the letters of alphabet, while the cursor is movable on the display in response to user input so as to allow the user to input a code word and/or other information.

The enabled, executable version 110 of the second set of program code 100 may comprise an analysis routine for processing measured signals or measurement data received on the input 40 from the sensor 10.

According to an embodiment of the invention the second set of program code 100 is disabled by means of encryption. Hence, according to this embodiment the second set of program code 100 is an encrypted set of data 100. The encrypted data 100 is decryptable. Decryption may be achieved by means of a decryption program routine, provided that a correct decryption key, e.g. in the form of a data word, is received. The decryption routine may be comprised in one of the basic functions 80, illustrated in Fig 3.

In the course of decrypting an encrypted set of data 100, the decrypted data 110 may be stored at a third memory location 112. When decrypted, the second set of program code is an executable version 110 of the second set of program code 100. Hence, the memory location 90 may store a disabled version of computer program code and, provided a correct key has been entered, the memory location 112 will provide access to an enabled version of that computer program code.

Although, in the above, enabling of program functions has been described in detail only for a single program function, it to be understood that a large number of analysis functions may be provided in a disabled state in the analysis apparatus 14.

The number disabled program functions stored by the apparatus 14 may be in the range from one to twenty-five, or even more. This advantageously leads to a wide selection of functions, and the apparatus 14 may be sold at a competitive and relatively low price in a version where only one or a few of the program functions are enabled. According to a preferred embodiment an enabled program function remains enabled for a limited amount of use such that when the limited amount of use has been consumed, the program function will automatically become disabled again. An additional amount of use of the program function can be added by means of a dedicated usage enabling procedure. Execution of the dedicated usage enabling procedure may require clearance by the distributor. This embodiment of the invention advantageously makes it possible to provide, on the market at a competitively low price, a condition analysis system comprising a wide variety of program functions so that users may obtain a very versatile instrument at low initial cost. The user may instead pay a certain amount of money for obtaining an additional amount of use of a selected program function.

According to an embodiment of the invention the apparatus 14 stores at least five different disabled program functions, when the apparatus is ready to be delivered to a customer. According to another embodiment the apparatus 14 stores at least fifteen

different disabled program functions upon delivery to a customer. According to some embodiments at least two of the initially disabled program functions are, when enabled, for generating indications of the condition of a machine in response to measured vibrations. According to preferred embodiments at least half of the initially disabled program functions are, when enabled, for generating indications of the condition of a machine in response to measured vibrations.

Each one of the disabled functions can be individually enabled in dependence of a key. According to some embodiments of the invention each function is individually enabled dependent on a unique key word. According to an embodiment a group of program functions can be enabled in dependence of one single keyword.

A Mechanical Key Embodiment

According to another embodiment the interface means in the apparatus 14 comprises a receptor for receiving a mechanical key (not shown). According to this embodiment an operator may introduce the key in the form of a mechanical key for the purpose of enabling an additional analysis apparatus function. The receptor for receiving a key may comprise contact means operating to enable the disabled data 100 on reception of the corresponding correct key. According to one version of this embodiment the correct mechanical key may be rotated to cause a contact device to close an electric contact coupled to the memory 60, thereby enabling the reading of a range of memory addresses. Following such a procedure, the data processing means 50 is capable of reading and executing the second set of program code 100 which is stored on said second memory segment 90, i.e. on said range of memory addresses.

A Procedure and a System Providing Tailored Functionality for Evaluating the Condition of a Machine

Analysis of a machine's vibration signature is valuable for reducing unscheduled down time, reducing downtime for repair, minimizing periodic disassembly of a machine for inspection and greatly reducing the probability of catastrophic and unexpected machine failure.

According to one embodiment of the invention, a manufacturer of condition monitoring systems may provide customers with a very versatile, yet non-expensive analysis apparatus 30. The analysis apparatus 14 according to this embodiment allows for "tailored" outfit of Machine Condition Monitoring functions (MCM functions), in accordance with the individual preference of each customer. Potential customers of condition monitoring apparatus range from maintenance personnel - spending all their professional time analysing the condition of machines with the use of advanced analysis functions - to workshop personnel with a need to make an occasional control of a few machines.

The workshop personnel usually requires only a few basic monitoring functions for detection of whether the condition of a machine is normal or abnormal. On detecting an abnormal condition, the workshop personnel may call for professional maintenance personnel to establish the exact nature of the problem, and for performing the necessary maintenance work. The professional maintenance personnel frequently needs and uses a broad range of evaluation functions making it possible to establish the nature of an abnormal machine condition. Hence, different users of an analysis apparatus 14 may pose very different demands on the function of the apparatus.

In order to satisfy this broad range of demands, an embodiment of the present condition analysis system includes an apparatus 14 having a plurality of Machine Condition Monitoring functions, each one of which may be activated on demand.

Figure 4 is a simplified illustration of a second embodiment of the memory 60 and its contents. As described above, the first memory segment 70 stores program code for controlling the analysis apparatus 14 to perform basic operations.

The second memory segment 90, illustrated in Figure 4, stores a second set of program code 100. The program code in segment 90, when run on the data processing means 50, will cause the analysis apparatus 14 to perform a first Machine Condition Monitoring function (MCM function) F1.

The memory 60 may also include a third memory segment 120, as illustrated in Figure 4, storing a third set of program code 130. The program code in segment 120, when run on the data processing means 50, will cause the analysis apparatus 14 to perform a second Machine Condition Monitoring function F2.

The memory 60 may comprise a large number of disabled functions F1, F2, F3... Fn, where n is a positive integer. Each one of the functions F1, F2, F3... Fn may be individually enabled as described elsewhere in this document.

Once a function F1, F2, F3... Fn has been enabled it may be individually activated on demand e.g. by an operator so that the program function causes the analysis apparatus to perform the tasks prescribed by the computer program function. Although the functions F1 and F2 have been described in Figure 4 as being stored on separate memory locations, for the purpose of simplifying the understanding of this embodiment of the invention, it is to be understood that the functions F1, F2, F3... Fn may be stored in other manners. Additionaly, one function Fi, where i is a integer in the range 1..n, may use some, or all, of the program code for another function Fj, where j is an integer in the range 1..n.

A Usage Debiting/Crediting Procedure

Figure 5 is a flow chart illustrating an embodiment of a procedure according to the invention. An operator planning to perform a round of measurements may first consider what type of measurements and analysis is to be done, i.e. what type of Machine Condition Monitoring function is required. The choice of Machine Condition Monitoring function depends on the type of machinery to be inspected, and on how advanced an evaluation the operator intends to achieve, as described above.

A user help function, provided among the basic functions 80 in the first memory segment 70, can be activated by the operator to provide information about the purpose of any individual function F1 - Fn. This can advantageously contribute to a stepwise increase of the competence of the operator, since the operator may start using relatively simple MCM functions and then, being informed by the user help function, the operator may choose to proceed to using more advanced functions.

Once the operator has decided that he will need to enable a presently disabled function from the group consisting of functions F1-Fn the operator may activate the Usage Debiting/Crediting Routine 132. The Usage Debiting/Crediting Routine 132 can also be used for changing the value of a level parameter. The value of the level parameter decides the extent to which the analysis apparatus 14 may be used, as described in further detail below.

The Usage Debiting/Crediting Routine 132 (Fig. 4) is one of the basic functions 80 in the first memory segment 70, which is described in connection with Fig 4 above.

By means of the user interface 102,106 (Figure 2) the operator can activate the Usage Debiting/Crediting Routine, as illustrated by step S110 in Fig.5.

In step S120 (Fig 5), the Usage Debiting/Crediting Routine 132 causes the apparatus 14 to display a list of the available functions, e.g. via the user interface 102/106 (Figure 2). This may include a listing of a plurality of different functions and an indication about status for each individual function. According to a preferred embodiment the status information indicates for each whether it is disabled or enabled. For the enabled functions the status information may include information about the remaining amount of use.

In step S130 the operator selects to buy more usage of a function. In response thereto a request for an additional amount of usage is generated (S140).

According to an embodiment the request includes information identifying the function whose usage is to be increased, and payment information. The payment information identifies a person responsible for paying the cost of the requested usage or, alternatively the payment information can in itself effect payment. The payment information may include data such as a credit card number.

According to another embodiment the payment information may include information indicating that payment has already been effected.

The request is delivered to the premises 28 of a supplier (S150). According to an embodiment the request is delivered by means of the communications network 18 (Fig 1). Hence, request may be delivered from the apparatus 14 to the server computer 20, e.g. via data communication.

At the supplier premises 28 the request is processed (S160), the processing including a verification step for establishing whether the request is to be granted or not. The verification may, for example, include an evaluation of the payment information to decide whether the payment information satisfies certain predetermined payment criteria. According to a preferred embodiment the request is processed automatically by the server computer 20.

According to an embodiment this payment information evaluation includes a step of checking whether the payment information indicates that payment has already been effected, or whether it merely indicates a person responsible for paying the cost. If the payment information merely indicates a person responsible for paying the cost, the server computer 20 may proceed to check with a dedicated database for establishing whether clearance may be given for this person. The dedicated database may include information about the financial situation for the person responsible for paying the cost. According to one embodiment, the server computer limits this clearance check to a verification using data in the database 22 internal to the premises of the supplier 28. According to another embodiment the payment evaluation includes a communication with a financial services database.

Step S170 illustrates that if step S160 results in the request being granted, the supplier will deliver a key to the client (S180).

In step S190 the key is received in the apparatus. The reception of a key may be achieved as described above.

After reception, there is a verification procedure S200 for ascertaining the validity of the key. The result of the verification procedure S200 is an acceptance or a discarding of the key. If the key is not accepted, the apparatus will provide a non-acceptance indication by means of the user interface 106 (Step S210).

If the key is accepted the apparatus 14 will, in response to the key, amend a level parameter to change an amount of usage status (step S220).

According to an embodiment, the key is associated with the selected function so that, when correctly applied to the apparatus 14, the key will increase the allowed amount of usage of that function. In other words, the key may cause a level parameter associated with the selected function to be amended. The level parameter associated with a selected function is a parameter whose purpose is to indicate how much the apparatus 14 may execute the selected function.

With reference to Fig 4, an embodiment of the invention involving a level parameter is described. According to this embodiment the level parameter may be a counter value, herein referred to as "Use_F_k", where k is an integer indicating the association with the corresponding function F1, F2, F3... Fn. Hence, function F1is associated with level parameter "Use_F_1", and function F2 is associated with level parameter "Use_F_2" etc. According to this embodiment, the key will include a first data portion for associating the key with the corresponding function F1, F2 or F3 etc; and a second data portion for indicating the amount of use purchased.

After execution of step S220, the user interface of the apparatus will present information (step S230) for the purpose of allowing the operator to select a next operation to be executed. This includes selecting between e.g. starting a measurement, returning to step S110 for repeating the above procedure, or turning off the apparatus 14.

According to an embodiment the above mentioned request includes information identifying the individual analysis apparatus, and payment information. The key to be received may cause a level parameter associated with the use of all relevant functions in that individual analysis apparatus to be amended. Hence, such a level parameter may be associated with all MCM functions.

According to an embodiment the above mentioned request includes information identifying the individual analysis apparatus, and the function whose usage is to be increased, and payment information.

Example 1

This example describes an embodiment relating to the above-mentioned procedure. When a client has purchased e.g. ten units of use for the computer program routine "Function_F1" (See Fig. 4), the amount indication portion of the key may cause the parameter Use_F1 to increase by ten units. Hence, if the parameter Use_F1 had a numerical value zero (0) before reception of the key, then the parameter Use_F1 will have numerical value "10" (ten) after correct reception of that key. For each execution of the computer program routine "Function_F1" the numerical value of the parameter Use_F1 will be decreased by one (1). When the computer program routine "Function_F1" has been executed ten times so that the parameter Use_F1 again has the numerical value zero (0), the computer program routine "Function_F1" will become disabled.
In order to enable the computer program routine "Function_F1", the client can purchase a new amount of use by means of the procedure described above.

Example 2

This example describes an embodiment similar to the Example 1 embodiment above. It is noted that in the Example 1 embodiment the computer program routine "Function_F1" becomes disabled when the parameter Use_F1 reaches a first reference value (zero in the example).
The method may also include the steps of:

reading a current value of said registered use;

comparing said current value with a second reference value;

registering use at a first rate when said current value is above the second reference value; and

registering use at a second rate when said current value is below the second reference value.

This advantageously enables a supplier to sell usage at different costs. When, according to one embodiment, a user has paid for a certain amount A_p of usage, the second reference value is a level indicating that the amount A_p of usage already paid for has been spent. This means that any further use will be usage which has not yet been paid for. By the feature of registering such further use at a second rate it is possible to charge a higher cost per unit of usage for such further use.

An Embodiment of a Usage Registering Procedure

Figure 6 is a flow chart illustrating an embodiment of a procedure according to the invention.

The procedure may start with step S230, i.e. the user interface of the apparatus presents information for the purpose of allowing the operator to select a next operation to be executed.

In step S240 the operator selects to request the apparatus to perform a Condition analysis function. This means that the operator may select one of the functions whose use is to be registered. The operator may do this by means of the user interface 102,106.

In a step 250 the computer program 80 (Figure 4) will in response to the operator input check whether the selected operation involves any of the of the functions whose use is to be registered. The functions whose use is to be registered includes

the above discussed MCM functions F1 - Fn. A function whose use is to be registered is referred to as a "restricted function" in the following text.

If the selection involves only unrestricted functions the apparatus 14 (Fig2) will initiate and perform such operation (step S260) and then return to step S230. If a restricted function is selected, the computer program 80 (Figure 4) will in response thereto check whether the selected function is enabled or disabled (Step S270).

If the selected function is disabled, the computer program 80 will present information to this effect (S280), and offer to proceed to any of steps S230, step S110 or S120, described above.

If the selected function is enabled, the computer program 80 will register the use of the selected restricted function (S290), and execute the selected restricted function (Step S300). Although Fig. 6 illustrates a certain order between activities, it to be understood that the invention is not restricted to performing the steps in that particular order. In particular, the registration of use (step S290) may be performed before or after or somewhere during the execution of the restricted function.

The use maybe registered by counting a duration of Execution of a restricted function, in which case the registration of use may include a registration of a start time in a step S290A (as indicated in Fig 6) and the registration of a stop time in a step S290B. In such an embodiment the step S290A may be performed immediately before the execution of the restricted function, and the step S290B is executed immediately thereafter.

After successful execution and registration of use the computer program 80 may update a status register (step S310). Such update may include updating any and all variables/parameters needed for delivering status information correctly next time

step S120 is performed (See Fig 5 and corresponding description). Hence, step S310 may include detection of a usage parameter value indicating that a certain act is to be performed in response to the changed status. For example, if a parameter indicates that all usage for one or all restricted functions has been spent, the said certain act may include disabling the restricted function or functions. Such disabling may include erasing a decrypted version 110, so that only encrypted versions remain.

Figure 7 is a physical embodiment of an apparatus 14. The apparatus has an apparatus body; and a display 106 provided on at least one surface of said apparatus body. Also provided on the body is a user input interface 102 comprising a key board.

The apparatus body is portable; and it is shaped and adapted to enable a one-hand grip, as illustrated in figure 9. Figure 9 illustrates a hand 140 of a user. Moreover the user input interface 102 is positioned and adapted so as to enable user interaction by means of the user hand 140. In the embodiment shown in Fig 9 the user input interface 102 is operable by means of a thumb 150 of the user.

Figure 8 is a side view of the apparatus shown in Figure 7. The apparatus body is provided with fasteners 160 for a wrist strap 170. The wrist strap 170 is illustrated in Figure 9.

The body also has a holder 180 for an elongated device. The elongated device may be a pen or a pointing device for user input via the display 106. The display 106 may be a touch sensitive display allowing user input by means of the pointing device.

Figure 10 is a top view of an embodiment of the apparatus 14, illustrating the physical dimensions thereof. Figure 11 is a side view of the apparatus shown in Figure 10.

The display 106 has an extension xd in a first direction and an extension Yd in a orthogonal direction such that the display area is at least 4125 mm^2.

The apparatus body has a first portion 190 adapted for gripping by a user. The first portion has an extension x1 in a first direction, an extension y1 in a second direction. The body has an extension z1 in a third direction, as illustrated in Figure 11. The body also has a second body portion 200 having an extension x2 in a first direction, an extension y2 in a second direction.

According to an embodiment:

x1 is less than 80 mm
y1 is less than 140mm
z1 is less than 35 mm
x2 is less than 100 mm
y2 is less than 160 mm

According to another embodiment :

x1 is less than 60 mm
y1 is less than 120mm
z1 is less than 30 mm
x2 is less than 80 mm
y2 is less than 140 mm

According to an embodiment the apparatus 14 has a body volume of less than 1006 250 mm^2, and said display has a display area of at least 4800 mm^2.

According to another embodiment the apparatus 14 has a body volume of less than 800 000 mm^2.

Claims

1. An apparatus for analysing the condition of a machine, comprising:

at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine;

data processing means for processing condition data dependent on said measurement data; said data processing means comprising means for performing a plurality of condition monitoring functions (F1, F2,Fn); and

a logger for registering use of at least one of said condition monitoring functions (F1, F2,Fn).

2. An apparatus for analysing the condition of a machine, comprising:

at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine;

data processing means for processing condition data dependent on said measurement data; said data processing means comprising means for performing a plurality of condition monitoring functions (F1, F2,Fn).

3. The apparatus according to claim 2, further comprising:

a logger for registering use of at least one of said condition monitoring functions (F1, F2,Fn).

4. The apparatus according to claim 1, 2 or 3 wherein

at least one of said condition monitoring functions (F1, F2,Fn) generates said condition data in response to measurement data indicative of vibration.

5. The apparatus according to any of claims 1 - 4, wherein

said at least one input includes an input adapted to receive shock pulse measurement data; said adapted input comprising means for treatment of said shock pulse measurement data and delivery of said treated data to said data processing means.

6. The apparatus according to any of claims 1 - 5, wherein

at least one of said condition monitoring functions (F1, F2,Fn) generates said condition data in response to measurement data indicative of temperature.

7. The apparatus according to claim 6, wherein

said at least one input includes an input adapted to receive measurement data indicative of temperature; said adapted input comprising means for treatment of said temperature measurement data and delivery of said treated data to said data processing means.

8. The apparatus according to any of claims 1 - 7, wherein

said at least one input includes at least one analogue-to-digital converter coupled so as to enable reception of an analogue signal from said sensor and delivery of a corresponding digital signal to said data processing means.

9. The apparatus according to any of claims 1 - 8, wherein

said plurality of condition monitoring functions (F1, F2,Fn) includes one or more functions selected from the group consisting of: vibration analysis, temperature analysis, shock pulse measuring, spectrum analysis of shock pulse measurement data, Fast Fourier Transformation of vibration measurement data, graphical presentation of condition data on a user interface, storage of condition data in a writeable information carrier on said machine, storage of condition data in a writeable information carrier in said apparatus, tachometering.

10. The apparatus according to any of claims 1 - 9, further comprising:

a communication port (16); wherein

said apparatus is adapted to be capable of delivering data indicative of said registered use on said communication port (16).

11. The apparatus according to any of claims 1 - 10, wherein:

at least one of said plurality of condition monitoring functions (F1, F2,Fn) has an enabled state and a disabled state.

12. The apparatus according to any of claims 1 - 10, wherein:

all or several of said plurality of condition monitoring functions (F1, F2,Fn) have an enabled state and a disabled state such that each of said all or several condition monitoring functions can be individually enabled or disabled.

13. The apparatus according to any of claims 1 - 12, further comprising:

means for comparing said registered use with a first reference value,

means for disabling said data processing means or at least one of said condition monitoring functions (F1, F2,Fn) in response to the outcome of said comparison.

14. The apparatus according to any of claims 1 - 13, further comprising:

key reception means adapted to allow further use of said data processing means in response to reception of a first key.

15. The apparatus according to any of claims 1 - 14, further comprising:

key reception means adapted to allow further use of a selected one of said condition monitoring functions (F1, F2,Fn) in response to reception of a key associated with said selected function.

16. The apparatus according to claim 14 or 15, wherein:

said key reception means includes a communication port (16); and

said key includes a key word comprising information indicative of an amount of usage to be allowed.

17. The apparatus according to any of claims 1 - 16, further comprising:

a user interface for allowing an operator to indicate a desire to execute a condition monitoring function (F1, F2,Fn);

means for checking whether the indicated function is disabled or enabled;

means for causing execution of said indicated function when enabled.

18. The apparatus according to claim 17, further comprising:

means for causing the data processing means to present information to the effect that the indicated function cannot be executed when the indicated function is disabled.

19. The apparatus according to any of claims 1 - 18, further comprising:

means for allowing an operator to indicate a desire to obtain an increased amount of use of a selected condition monitoring function (F1, F2,Fn);

means for generating a usage request message so that it includes information identifying said selected condition monitoring function (F1, F2,Fn).

20. The apparatus according to any of claims 1 - 19, wherein:

said logger is adapted to store at least two parameters (Use_F_1, Use_F_2); a first one of said at least two parameters being associated with an amount of use of a first condition monitoring function (F1, F2, Fn), and

a second one of said at least two parameters being associated with an amount of use of a second condition monitoring function (F1, F2, Fn).

21. The apparatus according to any of claims 1 - 20, further comprising:

means for reading a current value of said registered use;

means for comparing said current value with a second reference value;

means for registering use at a first rate when said current value is above the second reference value; and

means for registering use at a second rate when said current value is below the second reference value.

22. The apparatus according to any of claims 1 - 21, wherein:

said data processing means includes a Field Programmable Gate Array circuit.

23. The apparatus according to any of the preceding claims, having:

an apparatus body; and

a display provided on, at or in, said apparatus body.

24. The apparatus according to claim 23, wherein:

said display has a display area of at least 4125 mm^2.

25. The apparatus according to claim 23 or 24, wherein:

said apparatus body has a body volume of less than 1006 250 mm^2.

26. The apparatus according to any of claims 23 - 25, wherein:

said display has a display area of at least 4800 mm^2.

27. The apparatus according to claim 23 or 24, wherein:

said apparatus body has a body volume of less than 800 000 mm^2.

28. The apparatus according to any of the preceding claims, wherein:

said apparatus body is portable; and

said apparatus body is shaped and adapted to enable a one-hand grip;

said apparatus body including user interaction means adapted to enable user interaction by means of said one hand.

29. The apparatus according to any of the preceding claims, wherein:

said apparatus body is houses readable and writeable memory means having a storage capacity exceeding 8 megabits.

30. The apparatus according to claim 29, wherein:

said storage capacity exceeds 240 megabits.

31. The apparatus according to any of the preceding claims, wherein:

said apparatus body houses at least two data processing devices; one of said data processing devices being a Field Programmable Gate Array.

32. The apparatus according to any of the preceding claims, wherein:

said registered use is a parameter indicative of a number of executions of at least one of said condition monitoring functions (F1, F2,Fn).

33. The apparatus according to any of claims 1-31, wherein:

said registered use is a parameter indicative of an extent of time.

34. The apparatus according to any of the proceeding claims, wherein:

at least some of said plurality of condition monitoring functions (F1, F2,Fn) is at least partly embodied by computer program code.

35. An apparatus for monitoring the condition of a machine, comprising:

at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine;

data processing means (FPGA + Program) for processing condition data dependent on said measurement data; said data processing means comprising means for performing a at least two condition monitoring functions (F1, F2,Fn);

at least one of said plurality of condition monitoring functions (F1, F2,Fn) having a locked state and an unlocked state; said locked state prohibiting

complete execution of said condition monitoring function; and said unlocked state allowing execution;

means for changing the state of a selected condition monitoring function (F1, F2,Fn) between the locked state and the unlocked state.

36 The apparatus according to claim 35, further comprising:

key reception means adapted to allow use of a selected one of said condition monitoring functions (F1, F2,Fn) in response to reception of a key associated with said selected function;

a logger for registering use of at least one of said condition monitoring functions (F1, F2,Fn).

means for comparing said registered use with a first reference value,

means for disabling said data processing means or at least one of said condition monitoring functions (F1, F2,Fn) in response to the outcome of said comparison.

37. The apparatus according to claim 35, wherein

said data processing means comprises means for performing a plurality of condition monitoring functions (F1, F2,Fn); all or several of said plurality of condition monitoring functions (F1, F2,Fn) having a locked state and an unlocked state such that each of said all or several condition monitoring functions can be individually locked or unlocked.

38. The apparatus according to any of claims 35-37, wherein:

said apparatus body is houses readable and writeable memory means having a storage capacity exceeding 8 megabits.

39. The apparatus according to claim 38, wherein:

said storage capacity exceeds 240 megabits.

40. The apparatus according to any of claims 35-39, wherein:

said apparatus body houses at least two data processing devices; one of said data processing devices being a Field Programmable Gate Array.

41. A method of operating a system for analysing the condition of a machine, the system comprising a supplier part and a client part; said client part having:

a sensor for obtaining measurement data when said sensor is applied at a measuring point on the machine; and

an evaluator (FPGA + Program) for generating condition data dependent on said measurement data;

the method comprising the step of:

controlling said evaluator so as to disable at least a part of said evaluator after an amount of use.

42. The method according to claim 41 further comprising the step of:

measuring or detecting use of said evaluator; and wherein

said disabling is performed in response to said measured or detected use when said measured or detected use is indicative of a certain amount of use of said evaluator.

43. The method according to claim 41 or 42 wherein:

said disabling can be avoided by the reception, at said client part, of a first key.

44. The method according to claim 41 or 42, comprising the steps of:

enabling at least a part of said evaluator in response to a first key.

45. The method according to claim 43 or 44, comprising the steps of:

delivering said first key from said supplier part.

46. The method according to claim 43 or 44, comprising the steps of:

receiving, at said supplier part, a request for an amount of use for said evaluator; said request including information indicative of an identity of said evaluator;

generating, at said supplier part, said first key in dependence on said identity information; and

delivering said first key from said supplier part after a clearance of said request;

enabling further use of said evaluator in response to reception, at said client part, of said first key.

Abstract

An apparatus for analysing the condition of a machine, comprising:

at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine;

data processing means for processing condition data dependent on said measurement data; said data processing means comprising means for performing a plurality of condition monitoring functions (F1, F2,Fn); and

a logger for registering use of at least one of said condition monitoring functions (F1, F2,Fn).

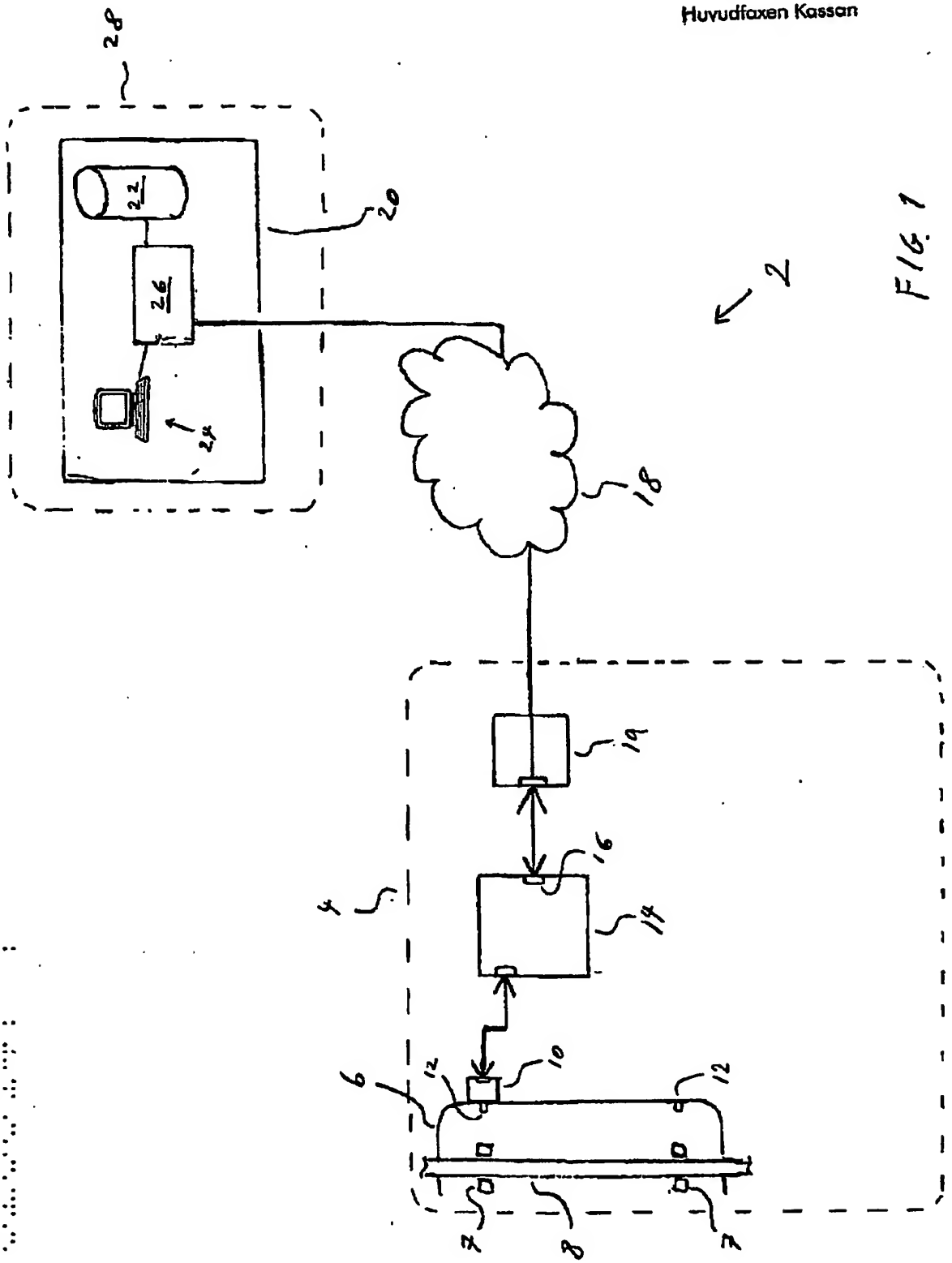


FIG. 1

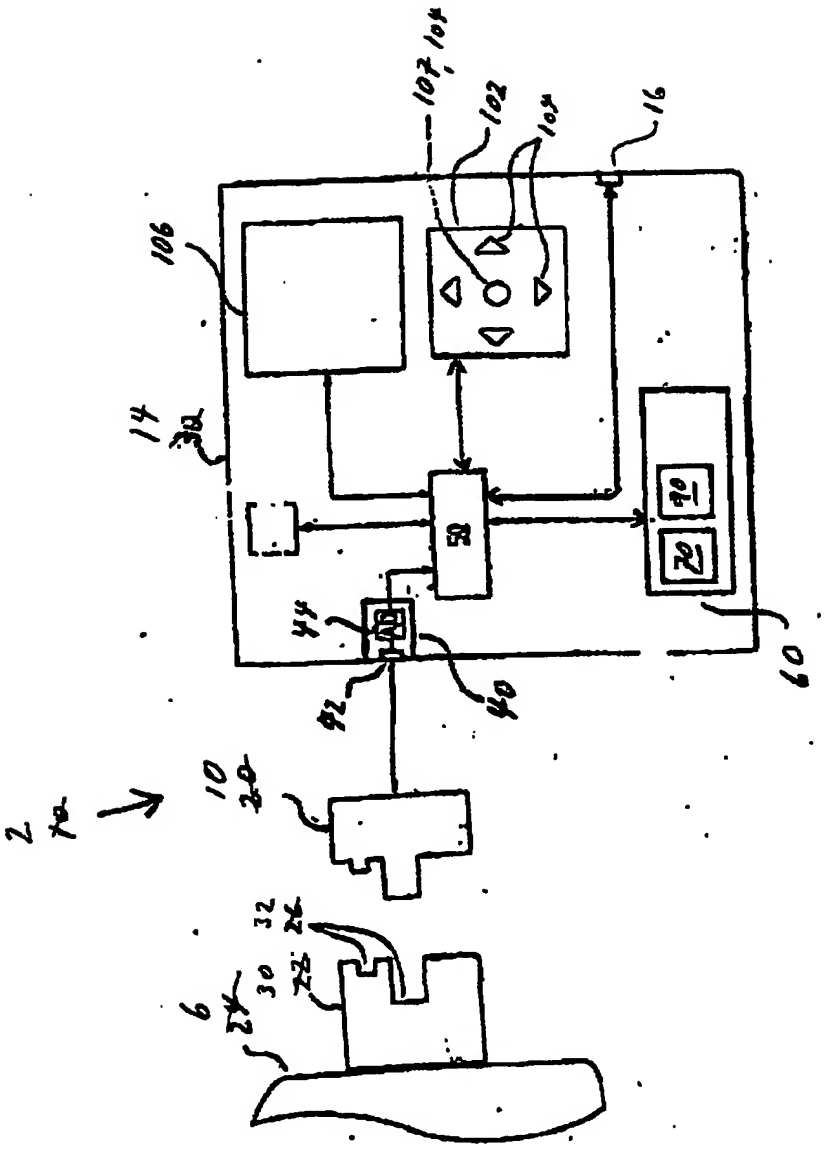


FIG 2

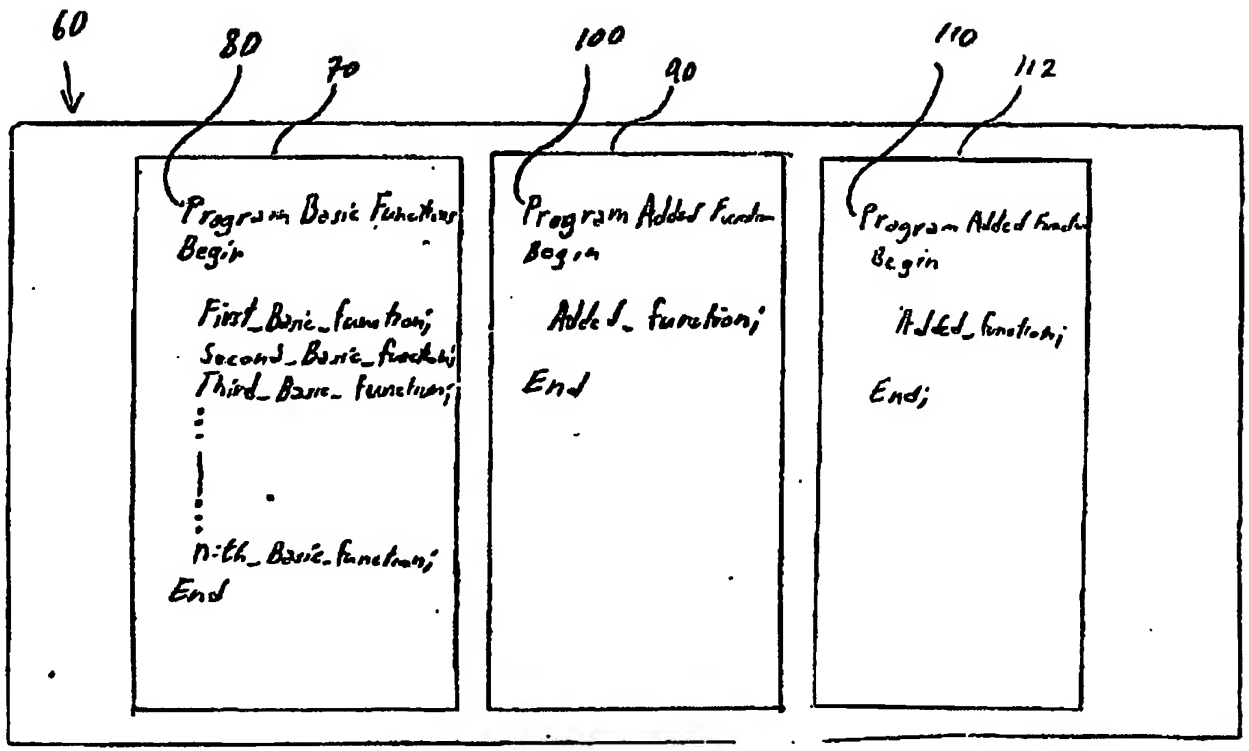


FIG. 3.

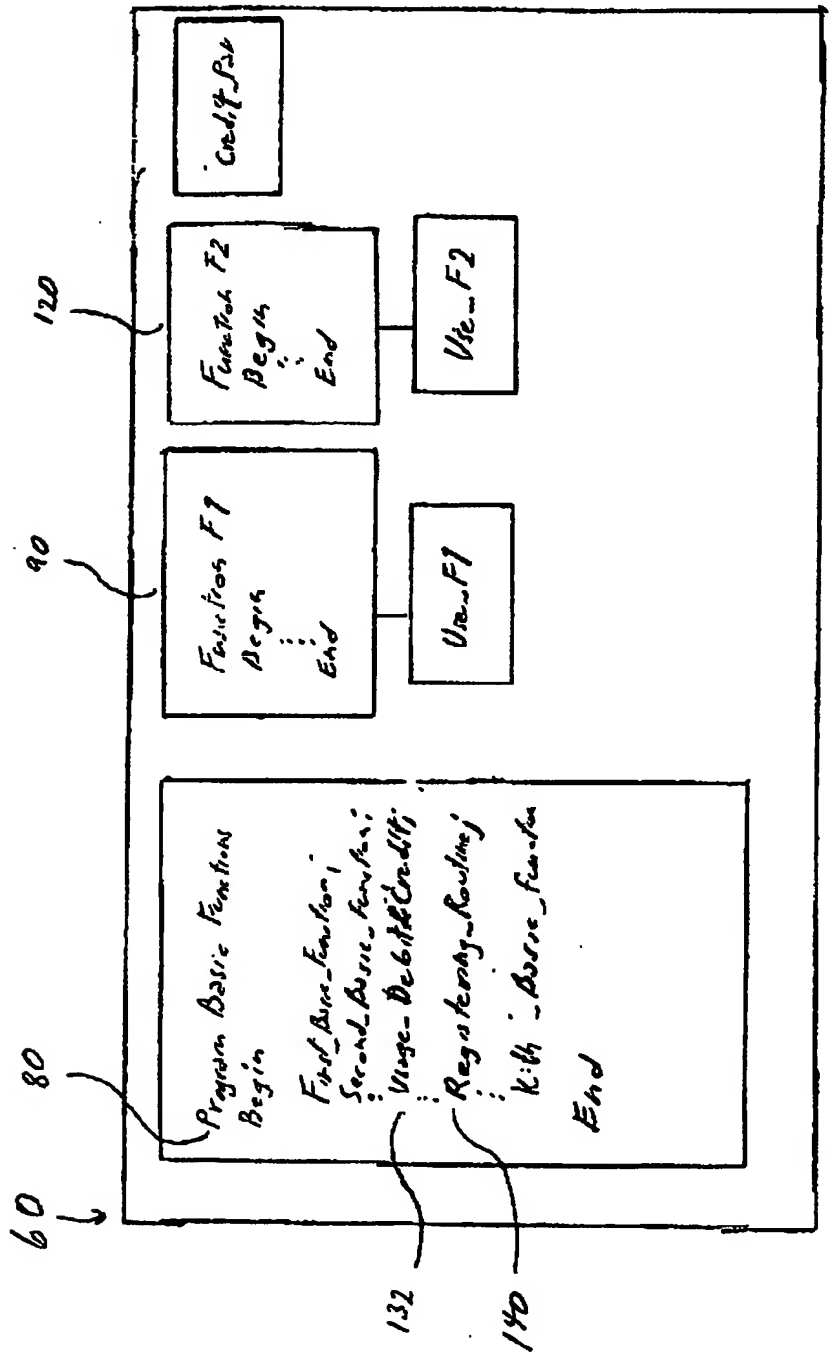


FIG. 4

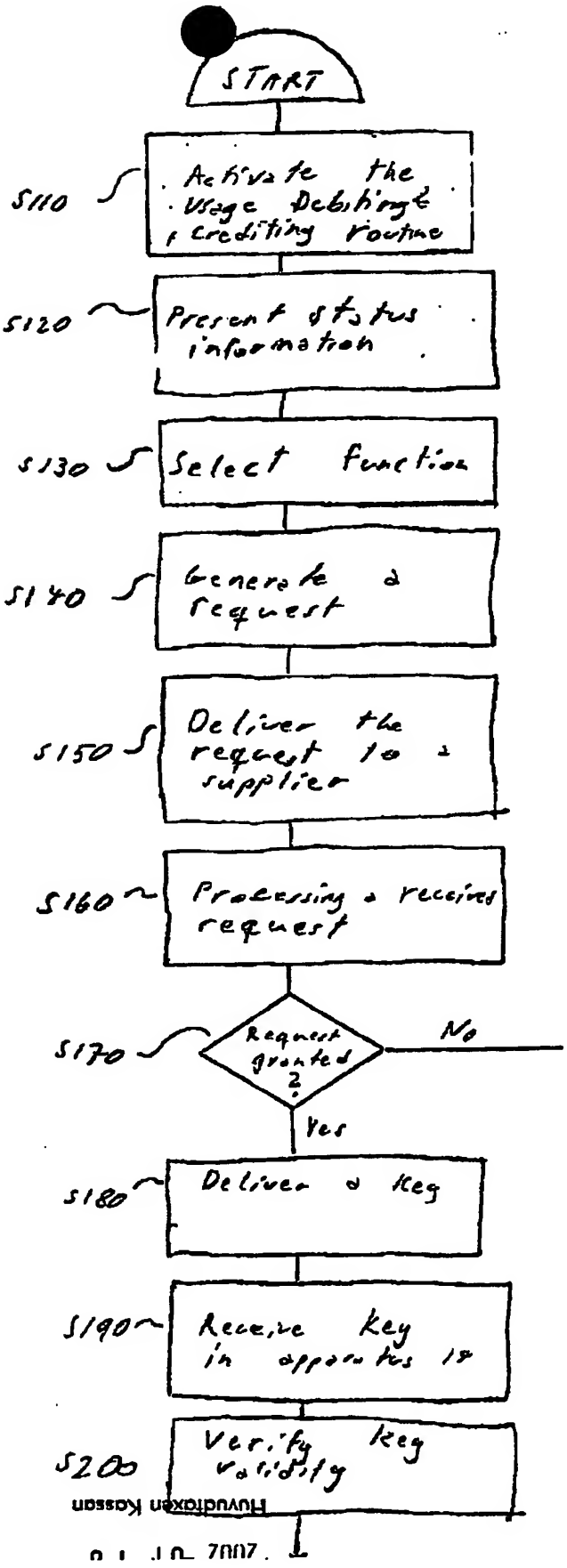

START
S110
Activate the Usage Debiting & crediting routine
S120
Present status information
S130
Select function
S140
Generate a request
S150
Deliver the request to a supplier
S160
Processing a received request
S170
Request granted ?
No
Yes
S180
Deliver a key
S190
Receive key in apparatus 1
S200
Verify key validity

FIG 5A

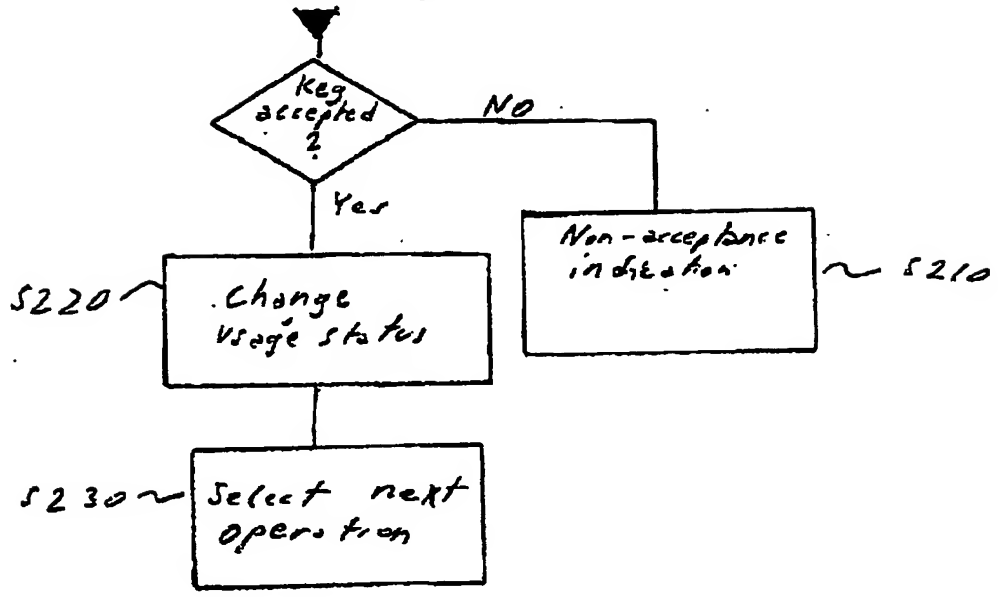


FIG. 5B

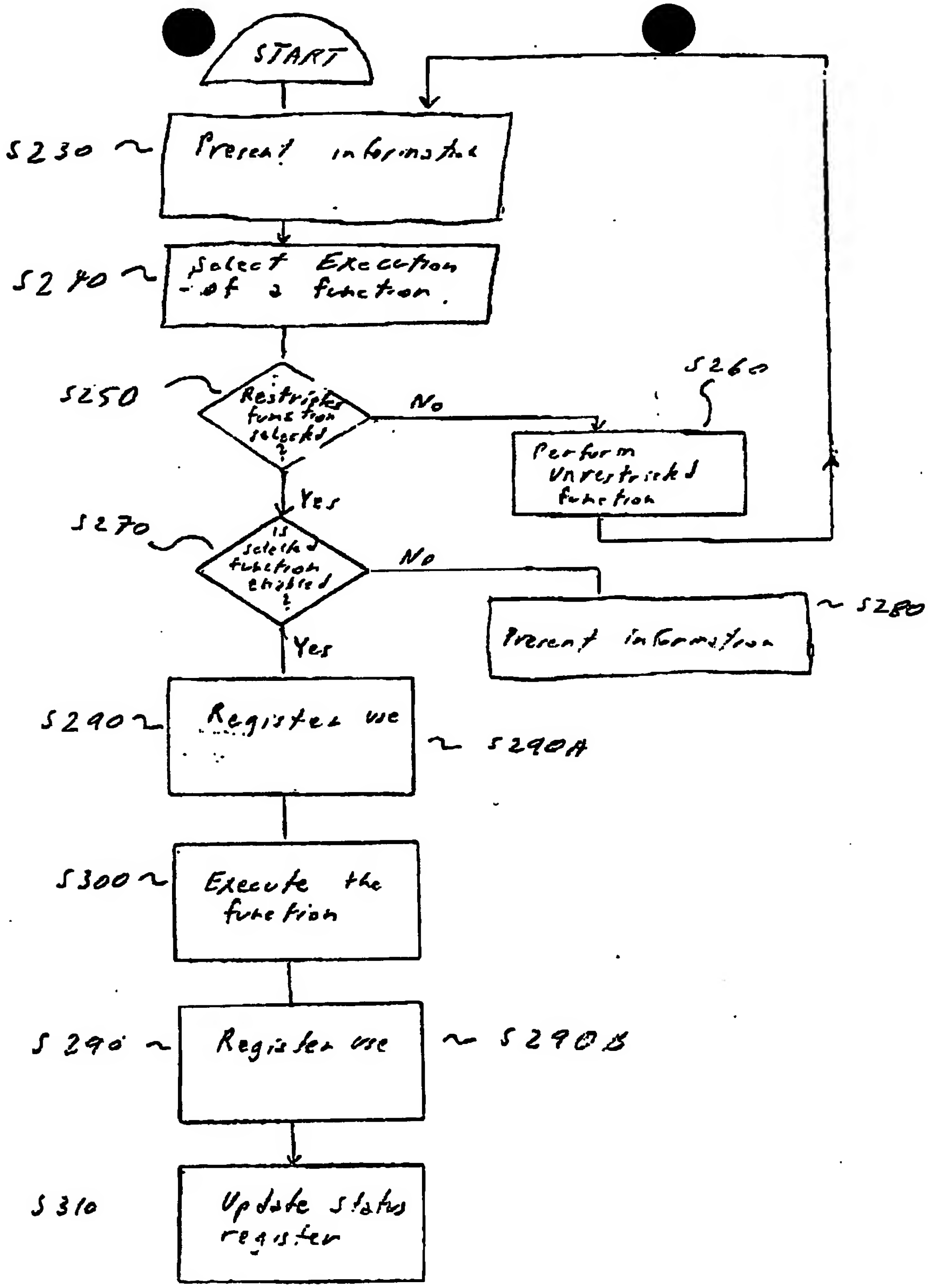


FIG. 6

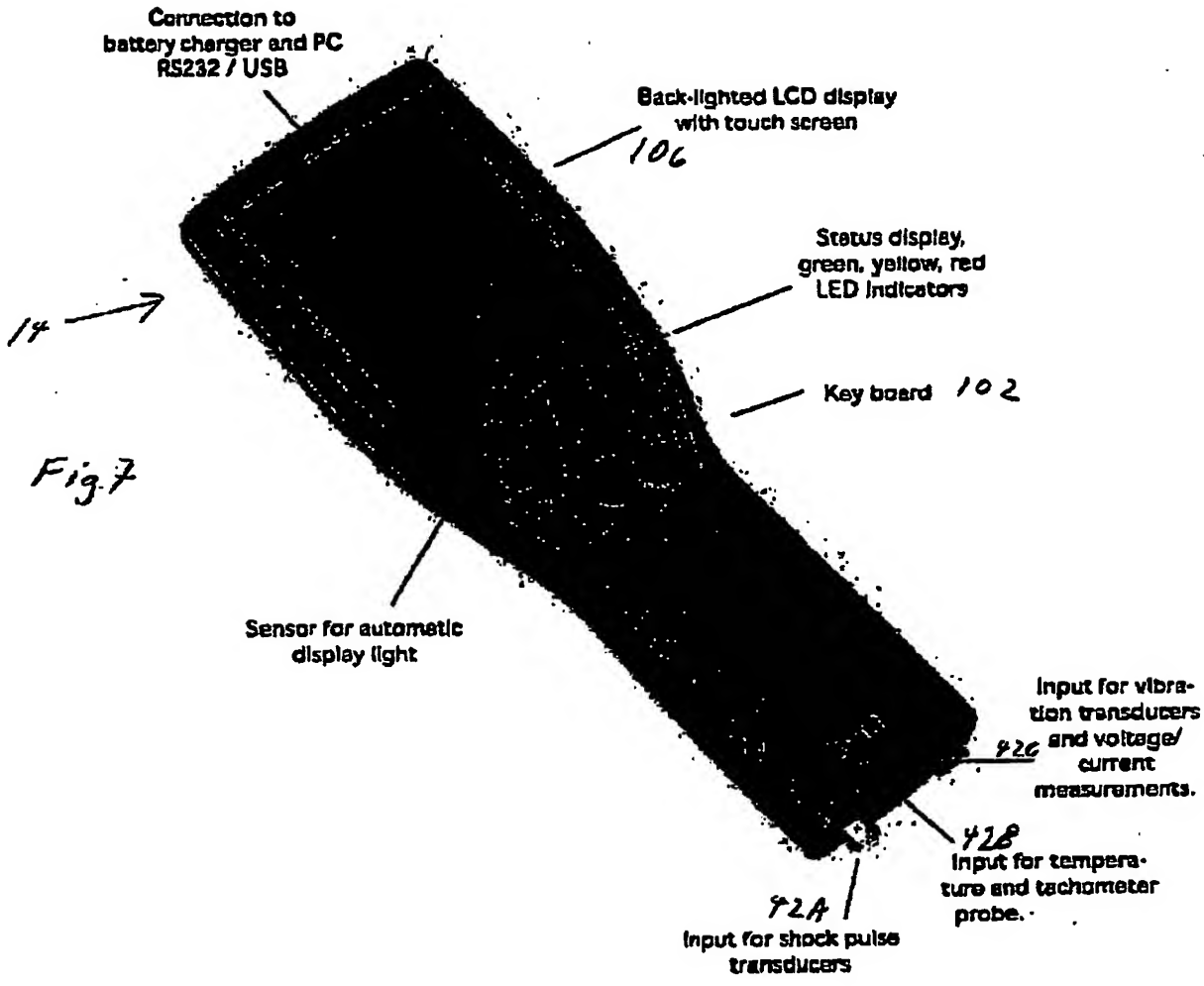


Fig. 7

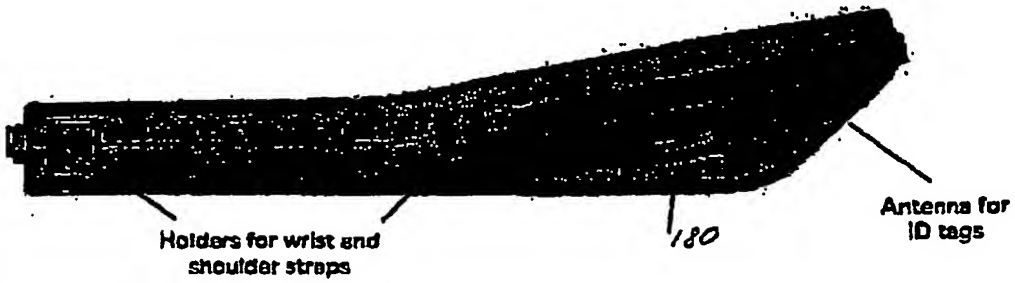
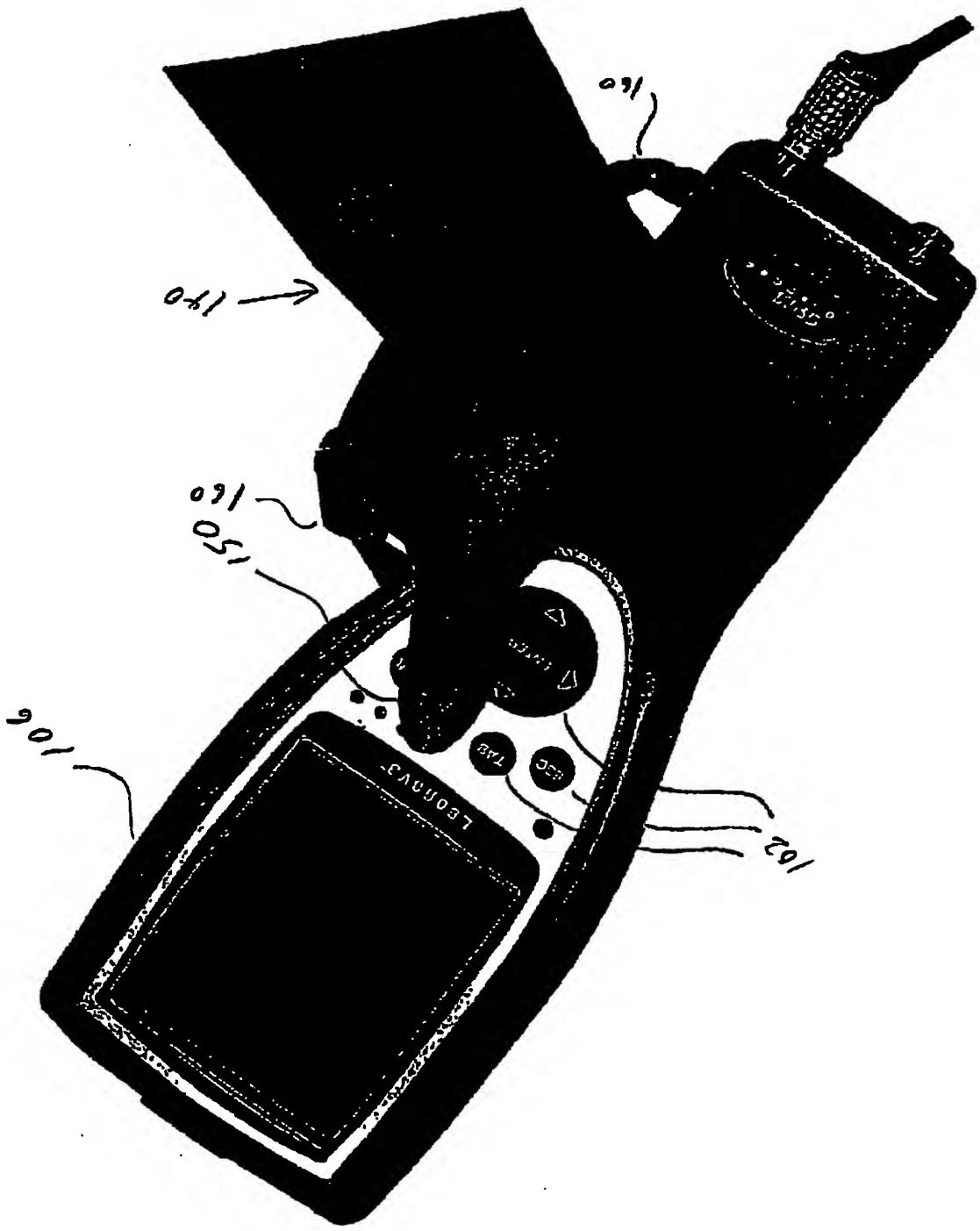


Fig. 8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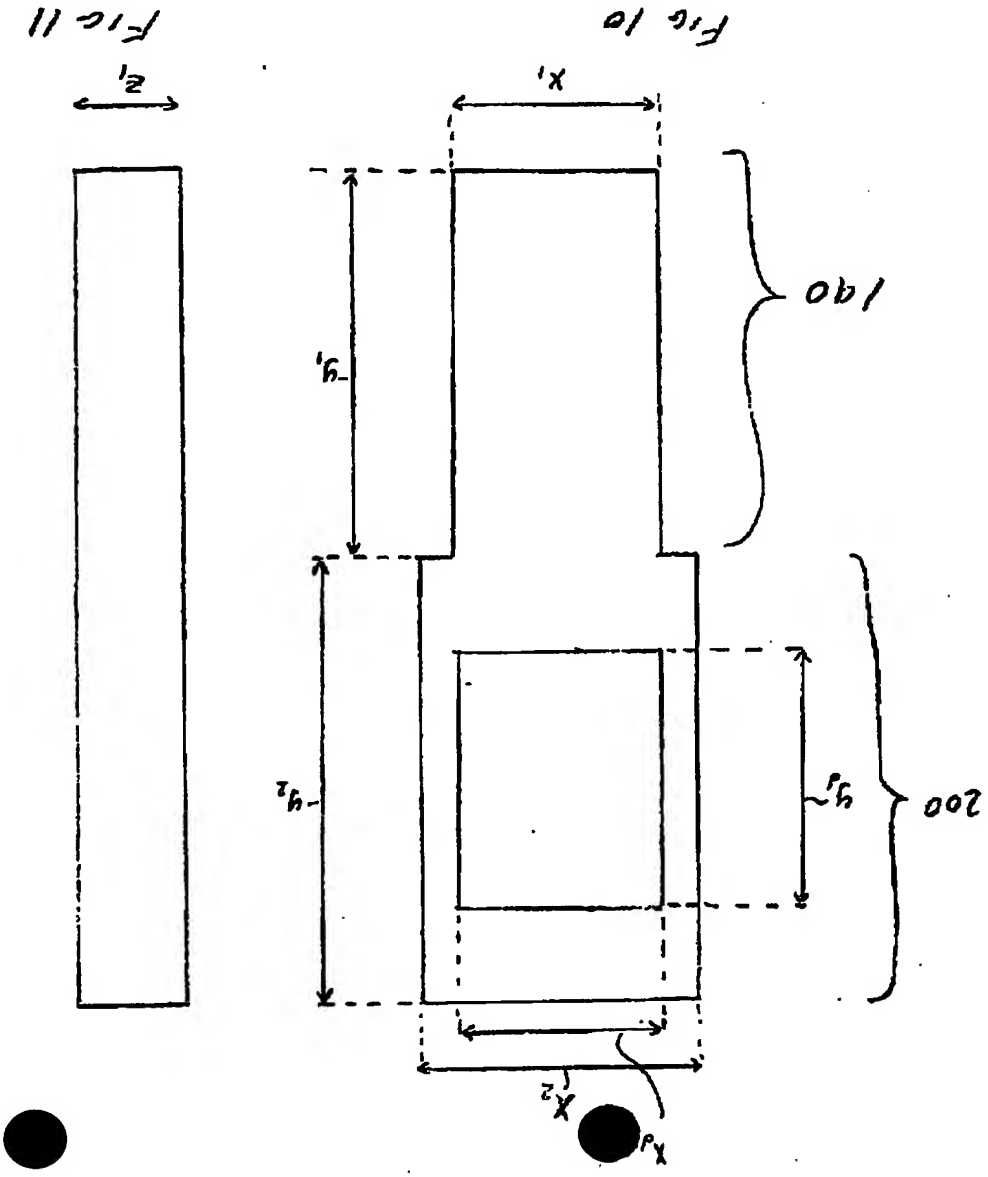

AN ANALYSIS SYSTEM

Technical Field of the Invention

The present invention relates to an apparatus for analysing the condition of a machine, and to a system for analysing the condition of a machine. The invention also relates to method of operating such a system.

Description of Related Art

Machines with moving parts are subject to wear with the passage of time, which often causes the condition of the machine to deteriorate. Examples of such machines with movable parts are motors, pumps, generators, compressors, lathes and CNC-machines. The movable parts may comprise a shaft and bearings.

In order to prevent machine failure, such machines should be subject to maintenance, depending on the condition of the machine. Therefore the operating condition of such a machine is preferably evaluated from time to time. The operating condition can be determined by measuring vibrations emanating from a bearing or by measuring temperature on the casing of the machine, which temperatures are dependent on the operating condition of the bearing. Such condition checks of machines with rotating or other moving parts are of great significance for safety and also for the length of the life of such machines. It is known to manually perform such measurements on machines. This ordinarily is done by an operator with the help of a measuring instrument performing measurements at measuring points on one or several machines.

A number of commercial instruments are available, which rely on the fact that defects in rolling-element bearings generate short pulses, usually called shock pulses. State of the art shock pulse measuring apparatuses may include proprietary technology for generating a value indicative of the condition of a bearing or a machine.